Current Approaches for Evaluating Potential Health Risks from Polychlorinated Biphenyls in Indoor School Air

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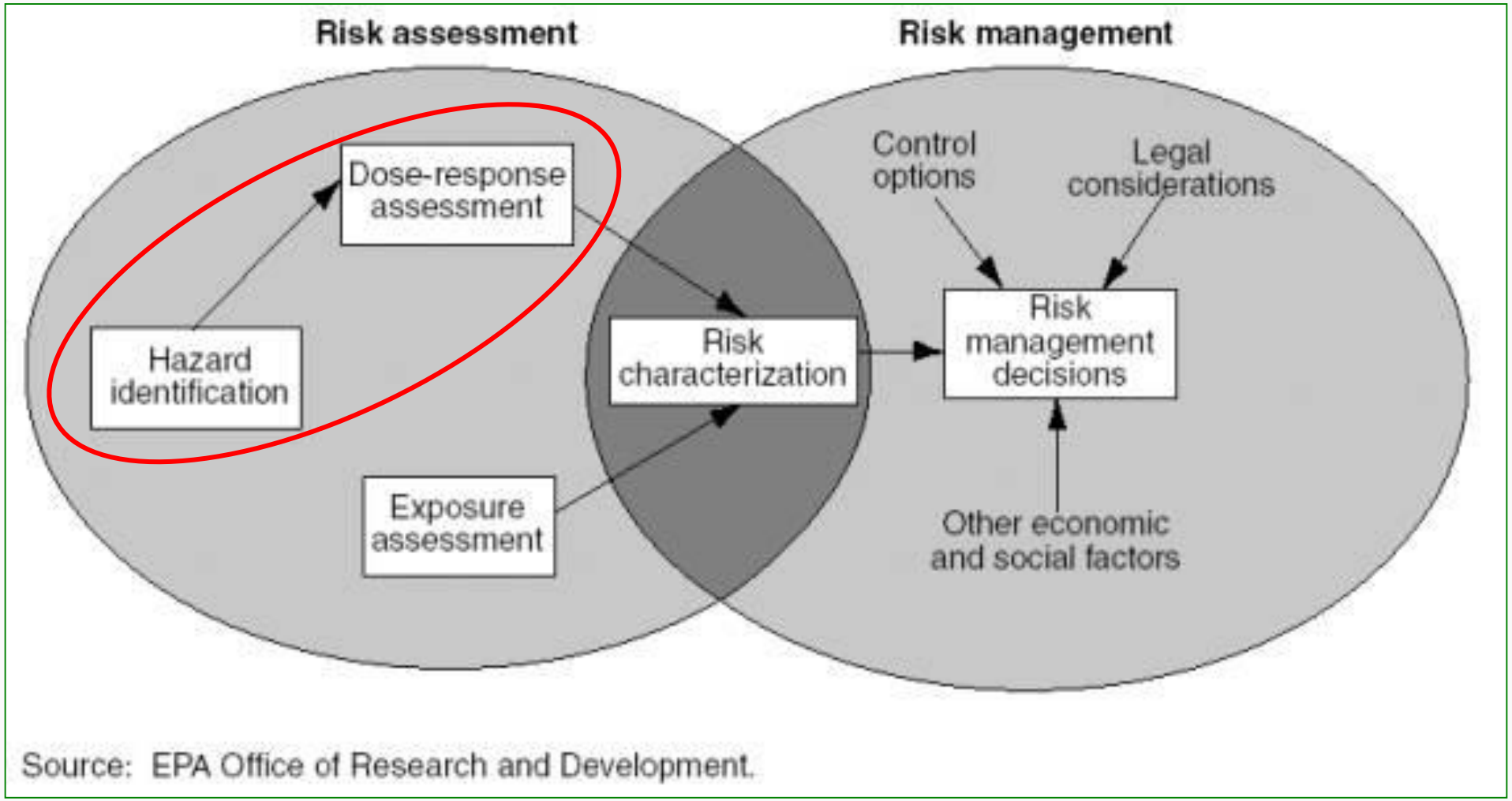
Overview

- Human health risk assessment of inhaled PCBs
  - Hazard identification
  - Dose-response assessment
  - Exposure assessment
  - Current approaches to minimize risk

The views expressed here are those of the author and do not necessarily reflect the views or policies of the U.S. EPA.

Human health risk assessment of inhaled PCBs



Reference Values Available on U.S. EPA's Integrated Risk Information System (IRIS)

Non-cancer values

- *An estimate (with uncertainty spanning perhaps an order of magnitude) of a daily oral exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime*
- Oral reference doses (RfDs)
  - Aroclor 1254 (20 ng/kg-day)
  - Aroclor 1016 (70 ng/kg-day)
- No inhalation reference concentration (RfC)

Reference Values Available on U.S. EPA's Integrated Risk Information System (IRIS)

Cancer values

- *An upper bound, approximating a 95% confidence limit, on the increased cancer risk from a lifetime exposure to an agent*
- Oral Slope Factors
  - High risk/persistence (2.0 per mg/kg-day)
  - Low risk/persistence (0.4 per mg/kg-day)
  - Lowest risk/persistence (0.07 per mg/kg-day)
- Inhalation Unit Risk
  - 0.0001 per $\mu g/m^3$ (extrapolated from the low risk/persistence slope factor)

Reference Values Available on U.S. EPA's Integrated Risk Information System (IRIS)

- Route-to-route extrapolation (e.g. oral-to-inhalation)
  - PCB toxicity is not expected to vary based on route of exposure.
  - Metabolic pathways are similar by each route.
  - Critical effects are systemic, and PCBs are generally not associated with respiratory effects.
  - PCBs are well-absorbed through both oral and inhalation routes.

Toxicological Database Supporting Reference Values

Outcome	Human (in vivo) Studies	Animal (in vivo) Studies	Lowest Adverse Effect Level (LOAEL) (mg/kg-day)
Reproductive	+	+++	0.08 (monkey)
Developmental	+	++	0.028 (monkey)
Neurological	++	+	0.006 (monkey)
Hepatic	+	++	0.06 (rats)
Gastrointestinal	+	+	0.94 (pigs)
Endocrine	-	++	0.09 (rats)
Respiratory	+	+	0.94 (pigs)
Immunologic / Dermal / Ocular	+	+++	0.005 (monkey)

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Aroclor 1254 RfD Derivation (IRIS)

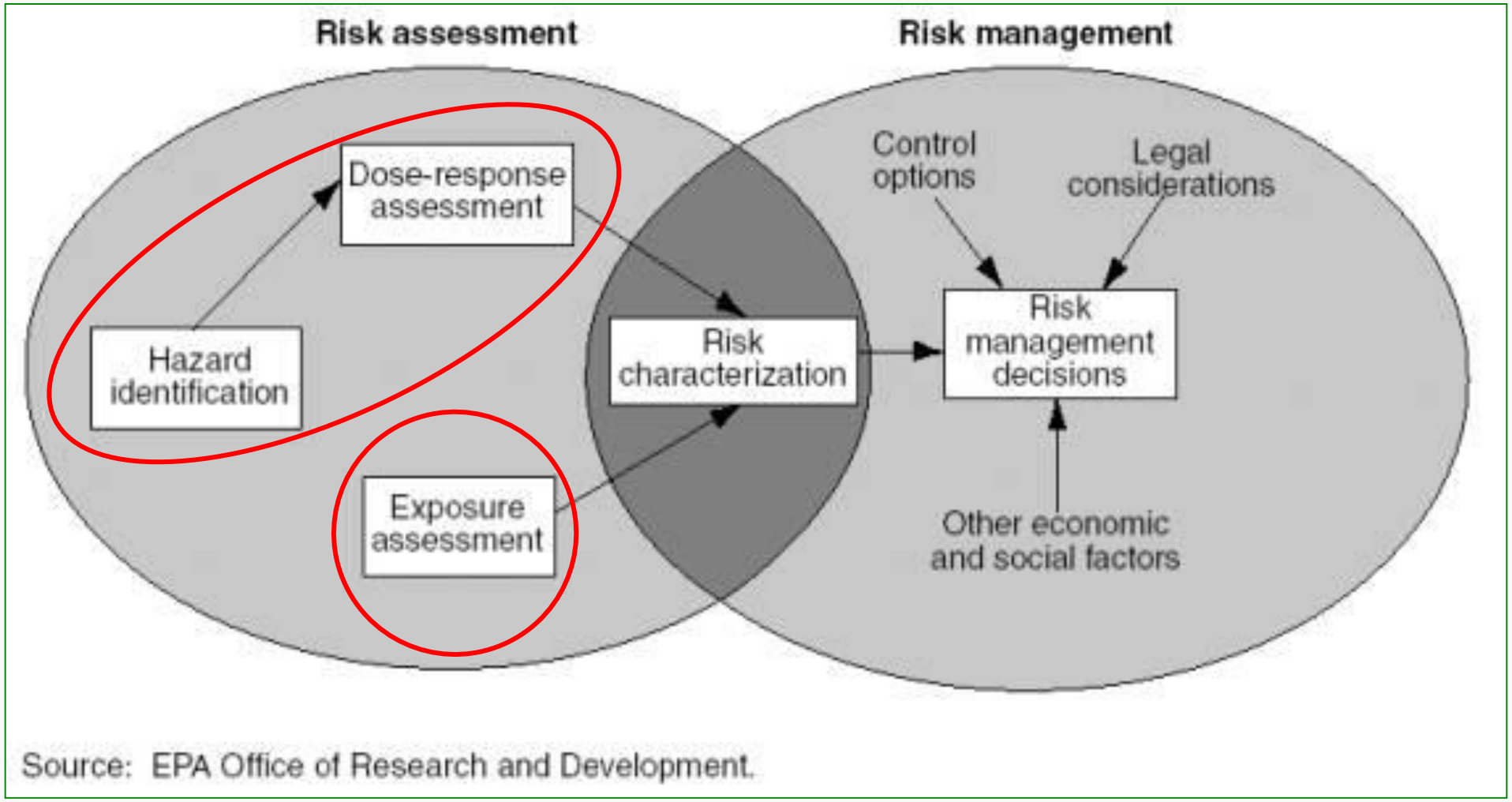
LOAEL (immunotoxicity)
0.005 mg/kg-day
= 5,000 ng/kg-day

Uncertainty Factors
÷10
(sensitive populations)
÷ $\sqrt{10}$
(monkeys ≠ humans)
÷$\sqrt{10}$
(effect at lowest tested dose)
÷$\sqrt{10}$
(study duration)

Aroclor 1254 RfD
20 ng/kg-day

An estimate (with uncertainty spanning perhaps an order of magnitude) of a daily oral exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime

Do PCBs in indoor air pose a health risk?



Source: EPA Office of Research and Development.

Exposure assessment in schools

- Populations
  - Students
  - Teachers/staff
  - Custodial worker

- Exposure routes
  - Oral (e.g., food, soil, dust)
  - Inhalation (e.g., indoor air)
  - Dermal (e.g., contact with soil and dust)

Exposure Scenarios

Assumptions

- Body weight
- Inhalation rate
- Fraction of time spent in school
- Total daily dust and soil ingestion
- Dermal exposure to indoor dust
- Relative absorption factors

Background exposures

- Dust and soil ingestion
- Indoor air inhalation (non-school)
- Outdoor air inhalation
- Dermal exposure to indoor dust
- Dietary background (U.S. FDA Total Diet Study)

See extended abstract for more information, including citations.

Risk Characterization

Derived Exposure Levels for Evaluation of PCBs in Indoor School Air (ELEs) that would yield an overall PCB exposure ≤ 20 ng PCB/kg-day (IRIS RfD for Aroclor 1254), taking into account background exposures.

$$\text{ELE}\ (\text{ng/m}^3) = \frac{(\text{RfD}\ (\text{ng/kg/day}) - \text{Background Dose}\ (\text{ng/kg/day})) \times \text{BW}\ (\text{kg})}{\text{Inhalation Rate}\ (\text{m}^3/\text{day}) \times \text{Relative Absorption} \times \text{Fraction of time spent in school}}$$

Exposure Levels for Evaluating PCBs in School Indoor Air (ng/m³)						
Age 1-<2 yr (Daycare)	Age 2-<3 yr (Daycare)	Age 3-<6 yr (Preschool)	Age 6-<12 yr (Elementary School)	Age 12-<15 yr (Middle School)	Age 15-19 yr (High School)	Age 19+ yr (Adults)
100	**100**	**200**	**300**	**500**	**600**	**500**

https://www.epa.gov/pcbs/exposure-levels-evaluation-polychlorinated-biphenyls-pcbs-indoor-school-air

Why Different ELEs for Different Age Groups?

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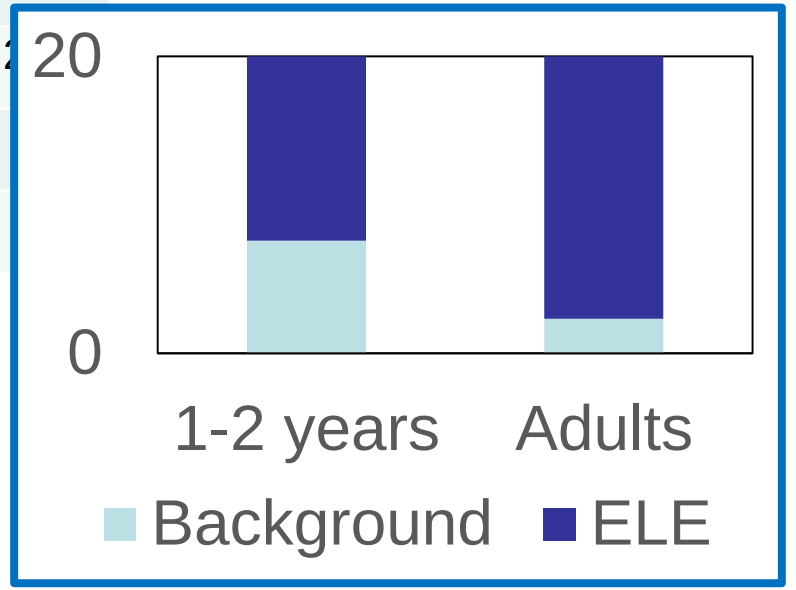
Exposure Factor (EF)	EF Data Used	
	Children 1-2 years	Adults
Dust Ingestion Rate	60 mg/d	27.5 mg/d
Soil Ingestion	50 mg/d	22.5 mg/d
Inhalation Rate	8.0 m^3/d	15.9 m^3/d
Skin Surface Area	1,155 cm^2	5,000 cm^2
Dust Adherence Factor	0.006 mg/cm^2-d	0.003 mg/cm^2
Body Weight	11.4 kg	71.8 kg
Time Spent Indoors	23.4 h/d	19.3 h/d



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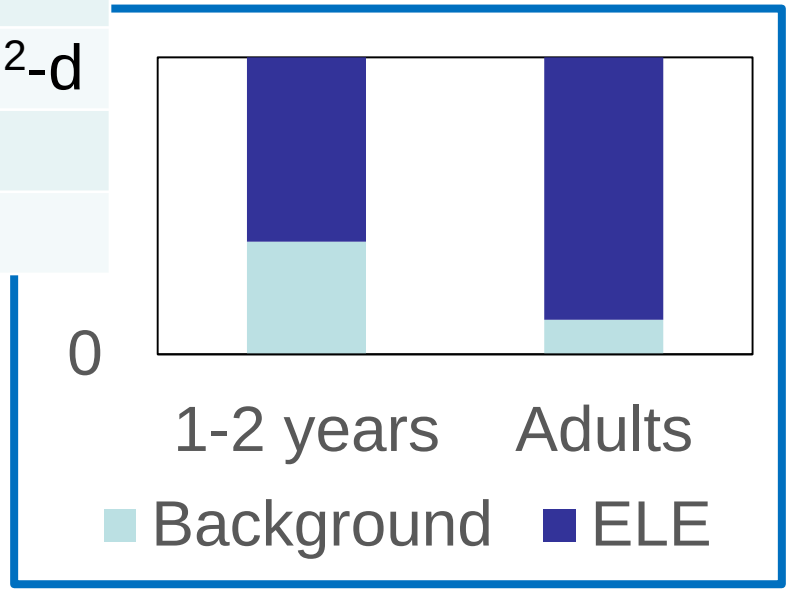

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Exposure Factor (EF)	EF Data Used		EF Data ÷ Body Weight	
	Children 1-2 years	Adults	Children 1-2 years	Adults
Dust Ingestion Rate	60 mg/d	27.5 mg/d	5.3 mg/kg-d	0.4 mg/kg-d
Soil Ingestion	50 mg/d	22.5 mg/d	4.4 mg/kg-d	0.3 mg/kg-d
Inhalation Rate	8.0 m^3/d	15.9 m^3/d	0.7 m^3/kg-d	0.2 m^3/kg-d
Skin Surface Area	1,155 cm^2	5,000 cm^2	101 cm^2/kg	70 cm^2/kg
Dust Adherence Factor	0.006 mg/cm^2-d	0.003 mg/cm^2-d	5.3E-4 mg/cm^2-kg-d	4.3E-5 mg/cm^2-kg-d
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PCB Dietary Intake	0.002 µg/kg-d	0.001 µg/kg-d	0.002 µg/kg-d	0.001 µg/kg-d

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Assumptions and Uncertainties

- ELEs are calculated using background exposure data that may or may not accurately characterize background exposures at a particular site of interest.
- ELEs are calculated using the RfD for Aroclor 1254, which assumes that an estimate of a safe level of oral exposure to this PCB mixture can be used to estimate a safe level of inhalation exposure to PCBs in indoor school air.

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100	**100**	**200**	**300**	**500**	**600**	**500**

PCB Exposure Sources Included in ELE Calculations

- Indoor air (background) = 6.9 ng/m^3
  - Based on mean total PCB concentration in air from 10 homes in Toronto, Canada
- Dust (school and non-school) = 0.22 µg/g
  - Based on mean total PCB concentration in dust samples collected from 20 homes in Austin, TX
- Soil (school and non-school) = 0.05 µg/g
  - Based on samples collected from parks in Helsinki, Finland
- Outdoor air (school and non-school) = 0.5 ng/m^3
  - Based on average total PCB concentration in outdoor air in Toronto, Canada
- Food (based on FDA total diet study) = 1-2 ng/kg-day (varies by age)

See extended abstract for source citations.

Impact of Site-Specific Exposure Data

ELE for elementary school children (6-12 years of age) = 300 ng/m^3				
Exposure Source	**PCBs @ bkgd**			
Indoor air (background) (ng/m^3)	6.9			
Outdoor air (non-school) (ng/m^3)	0.5			
Outdoor air (school) (ng/m^3)	0.5			
Dust (non-school) (µg/g)	0.22			
Dust (school) (µg/g)	0.22			
Soil (non-school) (µg/g)	0.05			
Soil (school) (µg/g)	0.05			
Food (ng/kg-d)	1			
Total exposure; PCBs in school indoor air are 300 ng/m^3 (ng/kg-d)	**20**			
Relationship to IRIS RfD	**=**			

Impact of Site-Specific Exposure Data

ELE for elementary school children (6-12 years of age) = 300 ng/m³				
Exposure Source	**PCBs @ bkgd**	**↑ PCBs school dust & soil**		
Indoor air (background) (ng/m³)	6.9	6.9		
Outdoor air (non-school) (ng/m³)	0.5	0.5		
Outdoor air (school) (ng/m³)	0.5	0.5		
Dust (non-school) (µg/g)	0.22	0.22		
Dust (school) (µg/g)	0.22	10		
Soil (non-school) (µg/g)	0.05	0.05		
Soil (school) (µg/g)	0.05	2.5		
Food (ng/kg-d)	1	1		
Total exposure; PCBs in school indoor air are 300 ng/m³ (ng/kg-d)	**20**	**21**		
Relationship to IRIS RfD	**=**	**>**		

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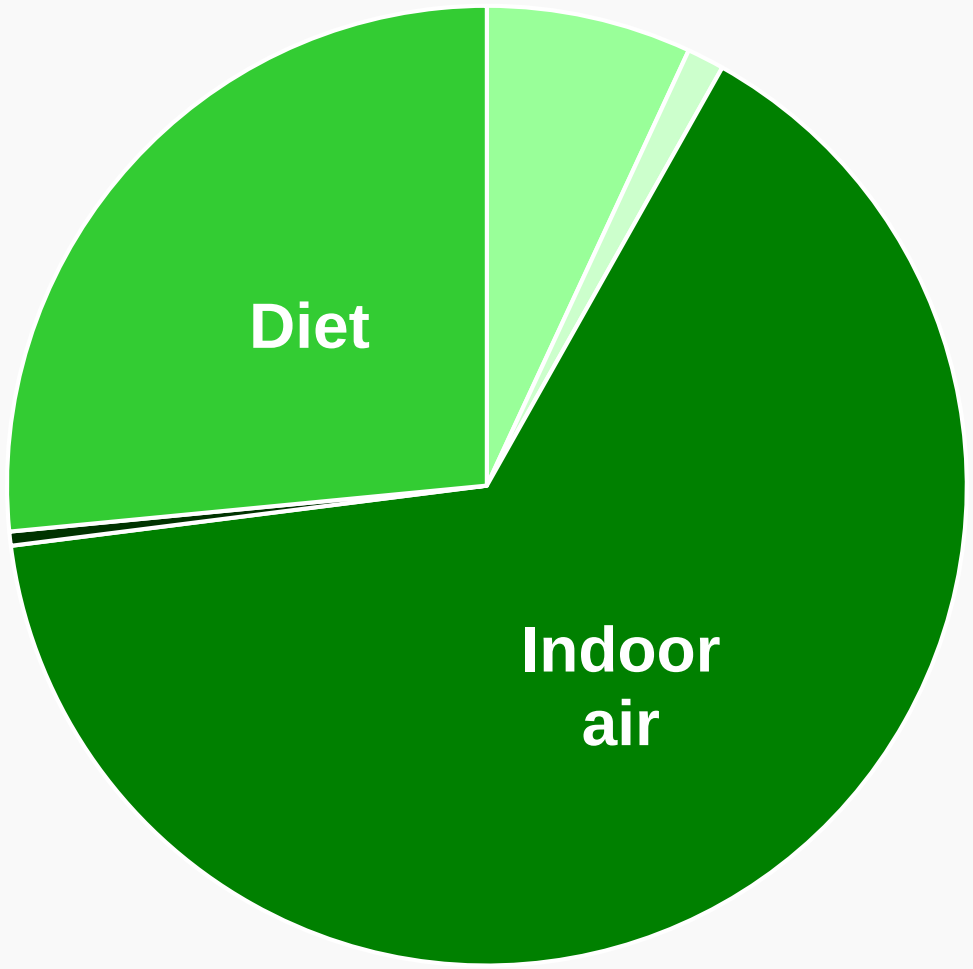
Exposure Source	**PCBs @ bkgd**	**↑ PCBs school dust & soil**	**↑ PCBs school dust & soil ↓ bkgd**	
Indoor air (background) (ng/m³)	6.9	6.9	2.8	
Outdoor air (non-school) (ng/m³)	0.5	0.5	0.1	
Outdoor air (school) (ng/m³)	0.5	0.5	0.5	
Dust (non-school) (µg/g)	0.22	0.22	0.11	
Dust (school) (µg/g)	0.22	10	10	
Soil (non-school) (µg/g)	0.05	0.05	0.005	
Soil (school) (µg/g)	0.05	2.5	2.5	
Food (ng/kg-d)	1	1	1	
Total exposure; PCBs in school indoor air are 300 ng/m³ (ng/kg-d)	**20**	**21**	**20**	
Relationship to IRIS RfD	**=**	**>**	**=**	

Relative Contributions of Various Sources of PCB Exposure



Impact of Site-Specific Exposure Data

ELE for elementary school children (6-12 years of age) = 300 ng/m³				
Exposure Source	**PCBs @ bkgd**	**↑ PCBs school dust & soil**	**↑ PCBs school dust & soil ↓ bkgd**	**No ↑ PCBs school dust & soil ↓ bkgd ↑ PCBs in food**
Indoor air (background) (ng/m³)	6.9	6.9	2.8	2.8
Outdoor air (non-school) (ng/m³)	0.5	0.5	0.1	0.1
Outdoor air (school) (ng/m³)	0.5	0.5	0.5	0.5
Dust (non-school) (µg/g)	0.22	0.22	0.11	0.11
Dust (school) (µg/g)	0.22	10	10	0.22
Soil (non-school) (µg/g)	0.05	0.05	0.005	0.005
Soil (school) (µg/g)	0.05	2.5	2.5	0.05
Food (ng/kg-d)	1	1	1	6
Total exposure; PCBs in school indoor air are 300 ng/m³ (ng/kg-d)	**20**	**21**	**20**	**22**
Relationship to IRIS RfD	**=**	**>**	**=**	**>**

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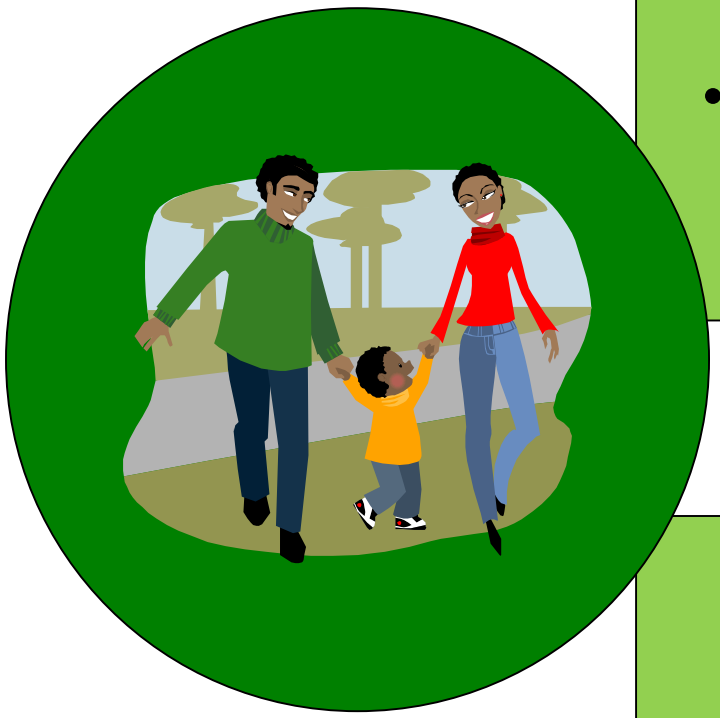
  - PCB toxicity is not expected to vary based on route of exposure.
  - Metabolic pathways are similar by each route.
  - Critical effects are systemic, and PCBs are generally not associated with respiratory effects.
  - PCBs are well-absorbed through both oral and inhalation routes.

Research to Reduce Uncertainty

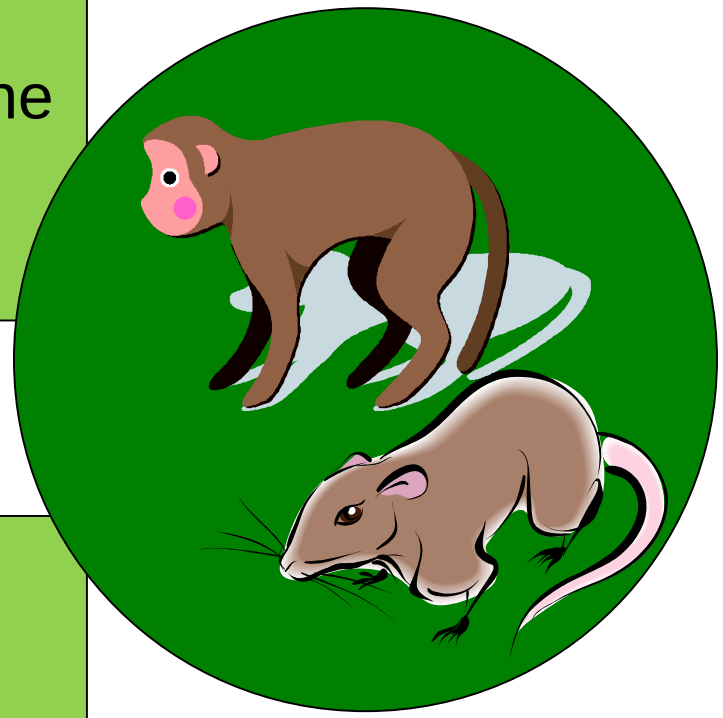


Accurate Exposure Assessment

- What is the congener profile of the PCB mixture?

Comprehensive Health Effect Evaluation

- Developmental neurotoxicity
- Immunotoxicity
- Changes in thyroid hormone levels



Summary

- EPA guidance and tools are available to help school administrators, building owners, and building managers to evaluate and reduce PCB exposures resulting from contaminated building materials.
- The Exposure Levels for Evaluation of PCBs in Indoor School Air (ELEs) can be used, with modification as appropriate, to guide thoughtful evaluation of indoor air quality in schools.

Contact Information
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